

DESIGN PATTERNS FOR COMPLEX LEARNING

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Abstract

A complex view of learning recognises that learning cannot be pre-determined by teaching, but is as much defined by circumstances and context as pre-defined learning objectives. Learning designs that accept uncertainty help us to envision classrooms and curricula that are open, dynamic and innovative. Architect Christopher Alexander's patterns and pattern language offer a means for researchers, practitioners, learners, and technologists to capture and share the emergent processes of complex learning. This paper examines the unique properties of patterns that support complex design tasks and suggests a design-based research framework for operationalising its practice. Through the thoughtful explication, mining and construction of patterns, all participants can contribute to a richer learning system.

Keywords

design methods, design patterns, pattern language, complexity

Education Practice

The discipline of learning design is struggling to cope with complexity. The literature is replete with recognition that our knowledge-based society demands a different attitude towards learning and its provision, one that spans a lifetime and is integrated into work and other contexts; that our notions of learning must extend beyond the psychological processes of an individual to one that recognises it is a property of complex systems; and that digital technologies offer a means for realising complex pedagogies that free formal education from some of the constraints of the past. These insights have influenced recent learning design theory and discourse: constructivist design theories for problem solving (Jonassen, 1999; Reigeluth, 1999; Schwarz, Lin, Brophy, & Bransford, 1999); calls for new directions on technology-based design (Kozma, 2000); design methodologies for acquiring complex skills (van Merriënboer, 1997); and a 'first principles of instruction' approach to instructional design (Merrill, 2002).

Yet there is a sense that this potential to realise complex pedagogies is mostly unmet. Teachers' practices often fall short of their espoused goals (Prosser & Trigwell, 1997). The factors that influence their practices are complex, contextually dependent on the constraints of the teaching environment such as their perceptions of student capabilities and assessment practices, and subject to individual variation (Bright, 2002). Learners are increasingly encouraged to be independent, autonomous and self-directed in their study (Candy, 2004). Responding to the ubiquity of digital technologies, the rapid pace of change and the need for continuing learning, students rarely pursue strategies as unsituated or unemergent as pre-defined curricula.

Noting the tensions in the design processes of standardisation versus improvisation, Fischer (1999) recognises that learners are not consumers of education, but rather co-designers of their own learning:

In a world that is not predictable, improvisation, evolution, and innovation are more than a luxury: they are a necessity. The challenge of design is not a matter of getting rid of the emergent, but rather of including it and making it an opportunity for more creative and more adequate solutions to problems.

(Fischer & Giaccardi, 2006, p. 1)

Such views are informed by complexity theories and it is this theoretical foundation that leads us to the use of patterns in learning design. This paper suggests that patterns and pattern language offer a means to embrace the emergent, and to reconcile the literature with practice, and designers with consumers. In the following section, we will briefly explore complexity theories, as a prelude to introducing patterns and pattern language.

Complexity in Education

Complexity theory is an attempt to understand systems that cannot be explained using the reductive methods of traditional science. Key characteristics of such systems are that they are open, that change is dynamic, adaptive and self-organising, that cause and effect are not linear, that interactions and relations among agents are emergent and unpredictable (see the Complexity and Education website at <http://www.complexityandeducation.ualberta.ca>).

Complexivists recognise that teaching does not necessarily cause learning (in linear terms), and the learning cannot be pre-determined by teaching. Davis and Sumara (1997b), whose 'enactivist' model of collective cognition is informed by complexity theory, explain that all contributing factors in any learning situation are intricately related and in constant flux. 'As the learner learns the context changes, simply because one of its components changes. Conversely as the context changes, so does the very identity of the learner ...' (p. 414).

Accepting uncertainty as part of the nature of education has profound implications for the way we teach and learn. Pre-defined outcomes must be 'set aside in favor of more holistic, all-at-once co-emergent curricula that are as much defined by circumstances, serendipity, and happenstance as they are by predetermined learning objectives' (Davis & Sumara, 1997a, p. 122). Learners learn on their own schedule, not when the curriculum dictates. They need to accept ambiguity and serendipity. Teachers need to accept students' abilities to structure their own learning. Learning designers should expect learners to customise their learning spaces (Nardi & O'Day, 1999). Content is uncertain; process, relationships and interaction are vital. It is in this context of uncertainty that we introduce patterns and pattern design as a means to negotiate these emergent roles.

Design patterns and pattern language

The common definition for design patterns — one that is potentially incomprehensible unless one is already familiar with patterns — is that they are solutions to recurring problems that can be used repeatedly in many contexts (Alexander, Ishikawa, & Silverstein, 1977; Guidelines for E-LEN Centres, 2004). However, the solutions are intentionally incomplete. Within their structure, patterns combine analysis and solutions to problems that are responsive to context, informed by theory and best practices. They focus and advise but do not constrain creativity. Thus, patterns guide rather than prescribe: a characteristic that makes them potentially valuable tools for designing complex learner managed systems.

The use of design patterns and pattern languages originates with architect Christopher Alexander, who sought to reconceptualise approaches to building design and town planning. Driven by the conviction that many forces that shape modern life damage our wellbeing, he sought deeper, recurring patterns in human activities that intuitively improve our environment. He articulated these patterns into a set of conceptual tools such that ordinary people as well as architects could shape the environment in which they live (Alexander, Ishikawa, & Silverstein, 1977).

Since its development in the 1970's, Alexander's thinking on design has received warm reception in surprisingly varied professions and disciplines. In software engineering, patterns have been used to represent successful models of information systems (see HillsideNet Patterns Library at <http://hillside.net/patterns/>) and human-computer interaction (for example, Tidwell, 1999). More recently, education technologists have looked to patterns to solve problems such as collaborative activities in Computer-Supported Collaborative Learning (CSCL) systems (Hernández Leo, Asenio Pérez, & Dimitriadis, 2004; Baggetun, Rusman, & Poggi, 2004) and learning management standards (Avgeriou, Papasalouros, Retalis, & Skordalakis, 2003), and to capture teaching practices in their respective disciplines (for example, from the Pedagogical Patterns project, Esckstein, Marquardt, Manns, & Wallingford, 2001, and also Bergin, 2002; Frizell & Hubscher, 2002).

Recently, we used a patterns approach to understanding digital technology support of lifelong learning', in the Distance Education programme at Athabasca University. The term 'lifelong learning, long divorced from its original meaning in Edgar Faure's 1972 seminal work for UNESCO, has become a ubiquitous slogan for government position papers and mission statements alike, and spawned an eclectic array of educational offerings (Friesen & Anderson, 2004) such 'that [it] has come to mean whatever its users want it to mean' (Knapper, 2001, p. 1). This is fortuitous for our purpose, for we can now directly seek patterns that depict the dynamics between learning and technologies without the potential ideological or pedagogical mask of teaching in formal education and training settings.

Structure and Elements of Design Patterns

'Go Berrypicking' is one example of the lifelong learning patterns we have identified (Figure 1; for others see <http://thecommonloon.motime.com/tag/patterns>). Based on Bates' (1989) Berrypicking model of information retrieval, it identifies a typical problem encountered in the information-rich world of the Internet: finding appropriate resources online. Pattern structure is fundamental to its value, and this pattern uses a variation of the Alexandrian pattern structure (other variations include Goodyear, Avgeriou, Baggetun, Bartouluzzi, Retalis, Ronteltap, & Rusman, 2004, and Bergin, 2002). Like all such patterns, it is written in second person, and in this case is directed to the learner, has a name, and these key elements separated by asterisks (***):

- The context for the problem that prevents an over-generalised solution.
- The forces that describe in what contexts users apply the pattern, followed by the **key problem** (in bold). The forces of the problem clash, constrain, and communicate the nature of both problem and solution.
- '**Therefore ...**' (Also in bold) introduces the archetypical solution. It describes how to apply the pattern correctly and includes consequences, limitations and disadvantages of the solution.
- Further *information and examples* (in italics) about its use, including references to related work and contraindications to support the pattern's use.

Taken together, the 'Go Berrypicking' pattern captures an essential aspect of the online search experience. However, it is not full featured enough to create a working blueprint for a complete online search. Rather, like all design patterns, this one makes sense when it is seen in context of its neighbouring patterns. Patterns are nested with other smaller, related patterns and within even larger patterns that describe supersets and whole structures such as a class, a community or an e-learning program. A pattern language is a structure for nested design patterns.

For example, 'Go Berrypicking' is part of a cluster of patterns for 'locating information sources and assistance' that includes 'Choose a well marked trail' and 'Trust a secondary source' among others (Figure 2; for a hyperlinked version see http://cider.athabascau.ca/Members/Shanta/pattern_map.html).

'Locating information sources and assistance' itself is a component of an online learning pattern language, for which we have used Candy's online learning model (2004) to lend structure to and represent the power of nested patterns. Our goal was not to structure a pattern language for lifelong learning, a rather large undertaking, but rather to explore its value for designing technology-supported lifelong learning spaces.

How do the structure and elements of design patterns support the emergent processes of complex learning? In the next section we present four unique characteristics of patterns that support learning design and examine ways in which patterns can be used to design learning experiences.

[title] GO BERRYPICKING**

[context] You want to search online about a topic that is unfamiliar to you.

[forces] The sheer volume and variability of sources on the internet make search complex. If you are unfamiliar with the domain, you may not know what sources exist, how to frame the research question, or what search terms to use. Unfortunately, search engines typically require that you present a structured, precise query that can be matched to the database contents to produce a single set of results (note: there are exceptions).

[problem] **An underdeveloped research question produces less meaningful search results.**

[solution] **Therefore, use the results to refine and redefine your research question until the results are meaningful.**

Search is iterative: the search question and result co-evolve. Start with just one feature of the broader topic and move through a wide variety of sources. Retrieve information a bit at a time, not all at once. Look for potential ideas and new directions and repeat with a refined query. Bates (1989) calls this strategy berrypicking and the shifting nature of queries an evolving search.

You may be tempted to restrict your search among a small set of familiar sites. (Tauscher & Greenberg, 1997 in Candy, 2004). However, a broadly scoped search will offer more opportunities. 'Berries are scattered on the bushes; they do not come in bunches' (Bates, 1998, p. 4).

Don't get lost. After pursuing a string of new directions, you may find yourself far a field from where you started, and unable to assimilate this new information into the original context. Fortunately, there are patterns for that too.

[further information] Bates (1989) suggests six ways to search for bits and pieces: *footnote chasing, citation searching, journal run, area scanning, subject searches in bibliographies and abstracts, and author searching*. These could be explicated as subpatterns.

The online bookshop, Amazon.com, lets you find books by linking to other books by the same author, on the same topic, with the same reviewer or even other purchasers.

CiteSeer, a database of computer and engineering documents that uses autonomous citation indexing, lets you query through a chain of documents.

Note: See family of patterns associated with assimilating information and insights.

Figure 1: Go Berrypicking, an example of a design pattern with key elements labelled

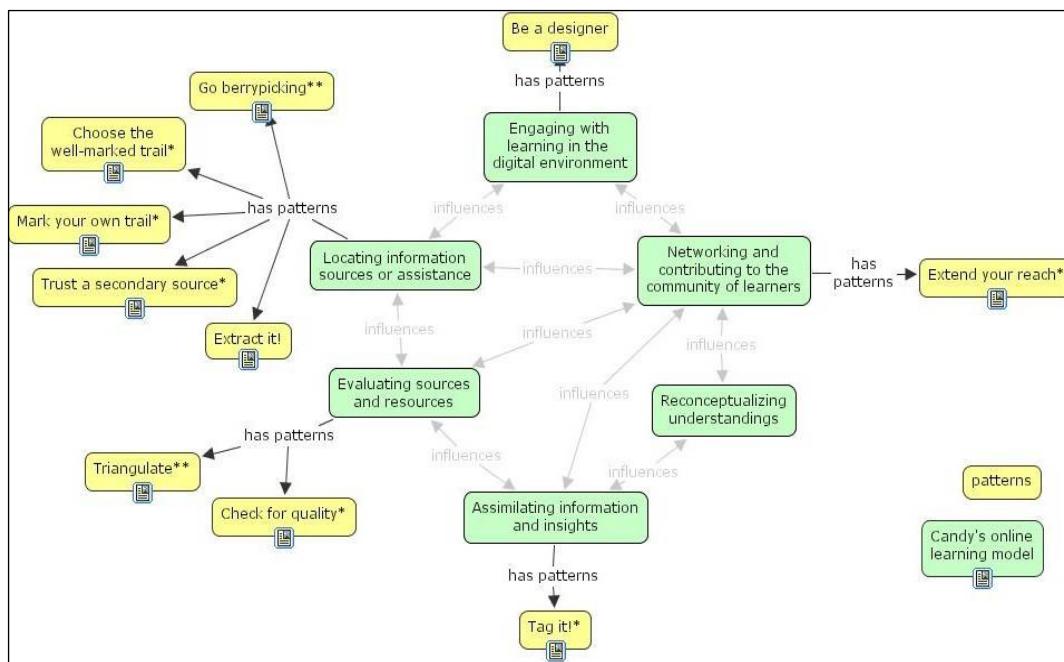


Figure 2: First step towards a lifelong learning pattern language

Patterns Support Complex Learning Design

The value of design patterns lies in their ability to manage complex design tasks. A design team can roam the nested structure from big picture patterns to more detailed ones, refining solutions as the nature of the problem becomes clearer or as the context evolves, yet never losing sight of the complex design. The pattern language creates common ground among all the members of a design team — researchers, practitioners and learners can all find better ways to express their educational beliefs, and share and explore their notions of good teaching and learning. Four properties of design patterns make this collaboration possible: adaptation, self-organisation, emergence and expression of values.

Adaptation

Patterns are designed to share expertise, but differences in context infer contextualisation in how the pattern is applied (Goodyear et al., 2004). For this reason, patterns are written at a level of abstraction in which the problem is recognisable rather than specified, and the solution is incomplete. A learner encountering an unfamiliar topic or a new search engine will still recognise the problem description in 'Go Berrypicking', but their specific activity will be influenced by their lack of experience. Implementing the pattern requires the 'learner as designer' to 'engage' (Davis & Sumara, 1997a) with the pattern, and to interpret the pedagogic descriptions to their own needs in ways that are not predictable. As the learner retrieves search results and finds potential ideas and new directions, the nature of their query changes, as do subsequent searches. Footnote chasing, citation searching, journal runs, and bibliography search patterns give a learner the power to create an infinite variety of searches.

Self-organisation

From a social cognition perspective Lave (1988, p. 1) noted that thinking is ‘a complex social phenomenon ... distributed — stretched over, not divided among — mind, body, activity and culturally organised settings’. A learner must concurrently attend to all levels at which it occurs: individually, in the school or workplace, the knowledge domain, the larger society, or the biosphere (Davis & Sumara, 1997a). Patterns reflect this organisation. Patterns nested within patterns reveal the interdependencies that cannot be dealt with in isolation, yet allow the learner to shift their focus from one aspect of the emerging design to another. In their online search, a learner is all at once chasing a specific footnote, attending to other potential ‘berries scattered on the bushes’ (Bates, 1998, p. 4), evaluating the source, and assessing their interest in the results. Berrypicking is all-at-once a complex collective of all these emergent forms.

Emergence

Repeatedly applying good patterns generates new patterns that lead to larger solutions addressing larger problems. Alexander calls this ‘generativity’, a property of the patterns that reside in our minds, which differ from their real-world counterparts:

The patterns in the world merely exist. But the same patterns in our minds are dynamic. They have force. They are generative. They tell us what to do; they tell us how we shall, or may, generate them; and they tell us too, that under certain circumstances, we must create them. Each pattern is a rule which describes what you have to do to generate the entity which it defines.

(Alexander, 1979, pp. 181–182)

The challenge in complex learning design is the means by which teachers as designers can converse with learners who change because they learn, and situations that change, as learners too become designers. Alexander, Ishikawa and Silverstein (1977) argue that patterns cannot be built at a single instant, but rather by patient ‘piecemeal growth.’ This resonates well with Schön’s (1983, p. 79) view of design as a ‘reflective conversation with the situation’. Researchers, practitioners and learners, designers all, respond incrementally to change with partial solutions to situations not well understood, which ‘talk back’ such that the next response is refined with new appreciation. For learners, this notion of incremental improvement demands that we need to make accessible the ideas that allow and inspire them to configure and co-create their own learning environments and learn from the new emerging patterns.

Expression of Values

Alexander’s patterns are suffused with democratic language and ideals of wellbeing and harmony to which town planners and architects should aspire. He speaks of ‘quality without a name’ or QWAN, a recognisable but incommunicable ideal evoked by words such as ‘beauty,’ ‘order,’ ‘symmetry,’ ‘life,’ ‘wholeness,’ ‘comfort’ and ‘emotional and cognitive resonance’ (Alexander, 1979). Patterns express not only architectural values, but also educational values. Goodyear et al. (2004) identify a ‘naïve and unsustainable belief’ that guidance about networked learning should be pedagogically (and even morally) neutral’. QWAN resists the temptation of offering an effective use of technology under the guise of implementing improved technical features and platforms.

Patterns in Practice

Consider the Educational Modelling Language, an XML-based language for specifying learning activities in different contexts and a cornerstone in the specification of the IMS Learning Design (IMS/LD) (Koper, 2001). Its significance lies in integrating learning design principles and activities into machine-readable international standards for eventual adoption by various e-learning tools. While the specification is strategy neutral, its sophisticated language precludes most educators from creating or adapting existing designs.

Design patterns have been proposed as a common language between educators and technologists to help educators develop pedagogically sound Learning Design scenarios (Rodriguez, Rifon, & Nistal, 2004; de Moura Filho & Derycke, 2005). Educators and technologists want to be designers. What about learners? IMS Learning Design places a high priority on learner instigated and managed learning. Support for learners depends on distributed, evolving networks of learners and on learning events strongly influenced by constructivism and active learner choice (Koper & Tattersall, 2004). Much effort by Koper and colleagues has focused on using software agents to perform assessments, develop and maintain learner profiles and facilitate learner positioning and choices within the learning networks (van Bruggen et al., 2004). Such learning networks expand learning experiences and choice, but require considerable commitment from learners who must actively acquire and contribute knowledge. Researchers recently expressed disappointment at low participation rates and noted evidence of lurking in studied networks (Hummel et al., 2005).

Fischer and colleagues have experienced the same gulf between expectations and reality. In their 'courses-as-seeds' model, Fischer and colleagues attempted to create a culture of 'informed participation' that reached beyond the context of the course (dePaula, Fischer, & Ostwald, 2001). Courses are seen as seeds rather than finished products, and students as designers who contribute and shape learning for themselves and others. In fact, the investigators found that learners preferred to be 'consumers' rather than 'designers' of education, expecting the instructor to lecture with well-defined materials, and concluded that informed participation demands more than expanding students' learning experiences. It requires a change in mindset and a profound cultural change by all participants.

Those who have applied ethnographic methods to find out what learners actually do when presented with resources and opportunities for self-managed e-learning (for example, Hara & Kling, 2000; Crook, 2002) have found learners' lived experiences to be richer and more complex than following the prescriptive pathways anticipated by their teachers. Alexander's design patterns are intended to give both professionals and ordinary people the means to design their own buildings, or at least be able to identify the patterns that allow them to discriminate between good and bad architecture. Pattern design offers a means to dialogue with learners about how they actually experience and behave, as distinct from how we might think they should experience and behave. Our lifelong learning design patterns speak directly to learners as designers, and are a modest attempt to include them in design conversations.

While a pattern approach suggests a methodology for learner-instigated design, it lacks a strategy for operational implementation. How might we welcome learners to the design team? Elsewhere we have proposed design-based research as a pragmatic framework for conducting education research in real educational contexts (Anderson, 2005). Like action research, design-based research is a systematic, iterative and pragmatic approach to solving practical problems in the context of use (Bannan-Ritland, 2003). Unlike action research, which is typically undertaken by practitioners, design-based research involves a partnership between practitioners and researchers. The emphasis on narrative reports and feedback cycles on complex interactions blurs the role of researchers and practitioners, and is sympathetic with the generativity of pattern design. Though not without its detractors (for example, Kelly, 2004), design-based research offers an integrative learning design framework for a patterns approach.

Conclusion

To conclude, it is useful to list the advantages a patterns approach offers to the language of learning design in its attempts to come to grips with complexity. Patterns reflect the characteristics of complex learning; they respond to the need for adaptation, self-organisation, emergence, and the expression of educational values in complex learning design. They offer a stable and coherent vocabulary for discussion of emerging new ideas, even when these ideas are inherently non-linear and unpredictable. Finally, they provide a common ground for researchers, practitioners, technologists and learners alike to understand, interpret, evaluate, and share educational practice. Used within a design-based research framework, design patterns offer a means to incrementally improve education practice.

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